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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,449,982**, on November 18, 2003, by **AURORA DIGITAL ADVERTISING INC.**, assignee of Dale Scott Marion, for "Three Dimensional Display Method, System and Apparatus".

PRIORITY DOCUMENT

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August 9, 2004

Date

ABSTRACT

[0056] A system, method and apparatus for providing a two dimensional image that will be perceived by the human visual perception system as a three dimensional image is disclosed. The system and apparatus preferably employ a clear rear projection screen onto which a rotating image of the object to be displayed is projected. The object moves at sufficient speed and has highlights, comprising specular highlights, ambient lighting, shadows and reflections, consistent with its display location so that the human visual perception system perceives the displayed image as a three dimensional one. The method comprises surveying the display site to identify important light sources and objects and to gather a reflection map which are both used to create the final displayed image.

Three Dimensional Display Method, System and Apparatus

RELATED APPLICATIONS

[0001] This application claims benefit from U.S. Provisional Patent Application 60/487,267, filed July 9, 2003 and the contents of this provisional application are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to display systems. More specifically, the present invention relates to display methods, systems and apparatus which exploit the human visual perceptual system to provide images on two dimensional image displays which are perceived by viewers as being three dimensional images.

BACKGROUND OF THE INVENTION

[0003] Many attempts have been made in the past to provide two dimensional displays which appear to be three dimensional. In Victorian times, stereophotographs were very popular. These images were produced with a binocular camera that made two images of the object being photographed, each image's perspective being spaced from the other. When viewed with a stereopticon which is a device that shows each of the viewers' eyes the appropriate one of the two images, a three dimensional image is perceived by the viewer.

[0004] In addition to stereophotographs, three dimensional motion pictures have been created wherein the members of the audience wear glasses, either with right and left lenses of two different color filters or polarizing lenses with two different polarizing angles and two motion pictures with slightly different perspectives are simultaneously projected through complementary filters onto the screen. This results in one eye of each audience member seeing one of the projected films and the second eye seeing another of the projected films, and the different perspectives of the films result in a perception by the audience members of a three dimensional display.

[0005] Both stereophotographs and three dimensional motion pictures suffer from disadvantages in that they require their viewers to use special hardware, the stereopticon or filter glasses, to view the image.

[0006] Another method of making a viewer perceive a three dimensional image from a two dimensional display is to employ the Pulfrich Effect, invented by Carl Pulfrich and published in *Die Naturwissenschaften*, in the June through September 1922 issues. The Pulfrich Effect makes use of an inherent effect of the human visual perception system. Specifically, a very dark filter is placed over one eye of the viewer who then observes a displayed object moving back and forth horizontally across a two

dimensional display. Due to latency in how the human brain processes low light images relative to normally lit images, the viewer perceives the displayed object as moving into and out of the two dimensional display. While interesting, the Pulfrich Effect has limited practical applications and still requires special observer hardware, in this case one dark filter.

[0007] Another technique for providing a three dimensional image from a two dimensional display is the hologram. In holography, an image is captured as an interference pattern at the film. Coherent light from a laser is reflected from an object to be imaged and is combined at the film with light from a reference beam. Holograms enable the viewer to view a true three-dimensional image which exhibits parallax.

[0008] Unfortunately, holograms also suffer from disadvantages in that they are difficult to create and display and are unsuited for video, motion pictures or the like. Also, holograms have constrained angles over which they can be viewed. Further, while they do produce accurate three dimensional images of objects, the color and appearance of the resulting image is not lifelike.

[0009] A method, system and apparatus which permits the relatively easy creation and display of video images which are perceived by viewers as three dimensional displays, without requiring the viewers to use any special hardware, is desired.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a novel system, method and apparatus of creating and displaying two dimensional displays that are perceived as three dimensional displays.

[0011] According to a first aspect of the present invention, there is provided a method of creating a final image which, when displayed at a target location, is perceived by viewers as being three dimensional, comprising the steps of: (i) selecting a target location for the display at a display site; (ii) surveying the display site to identify and characterize light sources and objects which would result in visual highlights on a object displayed at the target location; (iii) capturing a wide angle photograph of the display site about the target location; (iv) capturing video of the object to be displayed under a recreation of the characterized light sources and objects surveyed at the target location, the object moving in the video along a plane extending through the eyes of expected viewers; (v) applying the captured wide angle photograph as a reflection map to the captured video of the rotating object to create a final image; and (vi) displaying the final image at the site onto a screen positioned such that the final image appears at the target location.

[0012] Preferably, in step (iii) a panoramic photograph is captured. Also preferably, if the object is real, in step (iv) a mocking stage is constructed to recreate the light sources and objects characterized in

step (ii), the object is placed on said mocking stage in front of a chromakey backdrop and the video of the object is captured in step and the background removed by a chromakey process in step (iv).

[0013] If the object is virtual, preferably in step (iv) the characterized lights and objects from step (ii) are employed in computer animation system to light a model of the object to be displayed, step (iv) comprises rendering a video image of the object in said computer animation system and step (v) comprises applying the reflection map during the rendering process.

[0014] According to another aspect of the present invention, there is provided a system for displaying on a two dimensional display at a target location a final image of at least one object, the final image being perceived by viewers as a three dimensional image, comprising: a screen onto which the final image is displayed; a projector to display the final image onto the screen; and a video source providing a final image to the projector, the final image having visual highlights corresponding to the surrounding environment at the target location and showing the object moving such that a point on the object along a plane of the expected viewers eyes occurs at a rate of about at least three percent of the size of the object, measured through that plane, per second relative to the background.

[0015] According to yet another aspect of the present invention, there is provided a method of having the human visual perception system perceive an observed image of an object on a two dimensional display at a target location as a three dimensional image, comprising the steps of: (i) moving the object in the image such that a point on the object along a plane of the expected viewers eyes occurs at a rate of about at least three percent of the size of the object, measured through that plane, per second relative to the background; (ii) applying visual highlights to the object in the image, the visual highlights including specular highlight and shadows appropriate for the object at the target location; and (iii) obtaining a wide angle image of the surroundings of the target location and applying this wide angle image as a reflection map to the final image of the object.

[0016] The present invention provides significant advantages over two dimensional displays for purposes such as advertising and marketing, museum displays, educational system, etc. wherein the extra attention that a three dimensional display can attract will be most beneficial. By producing a final image which has been tailored to exploit appropriate characteristics of the human visual perception system, a simple yet effective display is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 shows a flowchart of the method of forming a final image in accordance with the present invention;

Figure 2 shows a schematic representation of a possible display site for a final display produced in accordance with the method of Figure 1;

Figure 3 shows a top view of a display system in accordance with another embodiment of the present invention; and

Figure 4 shows a side view of the embodiment of Figure 3.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The present inventor has determined that, by exploiting perceptual characteristics of the human visual perception system, a display of a properly constructed two dimensional animated image can be perceived by viewers as a three dimensional display, without requiring the viewers to use special viewing hardware.

[0019] Specifically, the present invention employs the fact the human visual perception system will attempt to perceive the display of an object rotating on an axis that is orthogonal to the plane of the viewer's eyes, or translating parallel to the plane of the viewer's eyes as being three dimensional. Provided that sufficient movement, either rotation or translation, of the object occurs, the perception holds true, even if the axis of rotation is not orthogonal to the plane of the viewer's eyes or the translational movement is not parallel to the plane, although better results are achieved the closer the axis of rotation is to being orthogonal and/or the translational movement is parallel.

[0020] The present invention also employs the fact that if a displayed object is displaying visual highlights (e.g. – specular highlights, shadows, reflections of surroundings, etc.) that are appropriate for the object's surroundings, the human visual perception system will attempt to perceive the display as a three dimensional one.

[0021] While the first of these characteristics of the human visual perception system can create a convincing perception of a 3D image, the present inventor has determined that, by appropriately combining these two principles, a more convincing three dimensional display can be produced from a two dimensional display.

[0022] As will be apparent, to exploit these characteristics, there are some limitations on the composition and positioning of the image to be displayed. Specifically, the above-mentioned characteristics of the human visual perception system cannot be exploited to display still images as the image must rotate about an axis or translate, as defined above, and objects to be displayed should advantageously have at least portions of their surface likely to create visual highlights as they rotate.

[0023] However, by creative construction of the image, these limitations can be effectively dealt with. For example, the displayed object can be moved vertically while being rotated, or can be translated while rotated, to maintain the viewer's visual interest in the display. Also, the object can, for brief periods of time, be moved vertically or horizontally without rotating provided that the viewpoint is simultaneously "zoomed" in, or out, on the object. Also, an object which does not have the desired surface characteristics to display visual highlights can have other objects, such as logos, text, etc. with the desired surface characteristics included in the image with the displayed object. Also, if a background image is included in the display, the object can be stationary while the background moves, as described below. As should now be apparent to those of skill in the art, by creative design of the final image, successful results can be obtained in a variety of manners, without unduly limiting the display.

[0024] Figure 1 shows a flowchart of the method of creating an image for a two dimensional display, which will be perceived as displaying three dimensional objects. At step 100 the site at which the display is to be shown is examined and a location for the display is determined. Figure 2 shows a schematic representation of a site 200 at which a display may be shown. Site 200 can be an area within a booth for the floor of a trade show, an area within a consumer store, a location within a museum, etc. In Figure 2, a location, hereinafter the "target location" has been selected for a screen 204 on which the finished image 208 is to be displayed. The target location is the location and viewing distance at which the object will appear on screen 204. For example, it may be that, as described below, the object to be displayed appears to be located two feet behind screen 204.

[0025] In a presently preferred embodiment of the invention, screen 204 is a clear rear projection screen, such as a HoloPro™ rear projection screen, sold by ProNova USD, Inc., Hoboken NJ. A projector 212, which can be any suitable video projector, a motion picture projector, etc., is located behind and appropriately aimed at screen 204 such that an image 208 projected by projector 212 will be displayed on screen 204. Projector 212 can be connected to any suitable video source, such as a computer system, DVD or videotape player, film, etc.

[0026] At step 104, a survey is performed of the site where the display is to be located. In this survey, light sources which would create visual highlights on a real object located at the target location are identified and their location with respect to the target location and their output levels are recorded. In Figure 2, ceiling lights 216, 220 and 224 and floor lamp 220 would be identified and their positions relative to the target location are recorded, along with their respective lighting levels at the target location. While it is preferred that a directional light meter be employed at the target location to determine the light received from each of the identified light sources, this level of accuracy is not

generally required and reasonable estimates of the amount of light received from each light source can be employed instead. Any identified colored light sources are also quantified with respect to their color in addition to their intensity.

[0027] In the survey, it is only necessary to identify and consider light sources which will contribute enough light to create visual highlights at the target location, hereinafter "light sources of interest". Thus, in Figure 2, ceiling light 232 has been omitted from the survey, as has floor lamp 236, as both of these light sources deliver too little light to the target location to create visual highlights at the target location.

[0028] Also in the survey, any objects which obscure part of a light source of interest are identified. In Figure 2, pillar 240 is identified and its general geometry, the fact that it extends from floor to ceiling and has a width of one foot, is noted. As pillar 244 does not obscure any light source of interest, it is omitted from the survey.

[0029] To simplify the survey process, it is also possible to merely consider objects and/or light sources within a volume of interest about the target location. In a present embodiment of the invention a sphere centered at the target location and with a ten foot radius has been successfully employed as a volume of interest to identify light sources and objects to be included in the survey. As will be apparent to those of skill in the art, different sized spheres of interest, or other volumetric shapes of interest, can be employed under differing conditions. For example, if the ceiling lights in Figure 2 are high output gas discharge lamps (such as mercury vapor lamps) a sphere with a radius of larger than 10 feet may be employed. Similarly, if the ceiling lights of Figure 2 are low level lights, such as dimmed halogen lights, or indirect lighting sources, a sphere with a radius of less than ten feet can be employed. Generally, the intent is to perform the survey within a volume of interest which encompasses all lights and/or objects which can create visual highlights on a real object located at the target location. If a light meter is employed to measure light levels received at the target location from various sources, then an appropriate volume can effectively be selected as objects of interest will be readily identifiable.

[0030] After the survey has been successfully completed, the process continues at step 108 where reflection information is captured at the target location. Specifically, a panoramic photograph is taken, centered at the target location, around a plane parallel to the floor of the location. This panoramic photograph can be captured with a special panoramic camera or, as in a present embodiment of the invention, the panoramic photograph is constructed from a series of six overlapping photographs, taken from the target location at 60 degree headings and which are subsequently "stitched" together with a suitable software program, such as Adobe Photoshop™, MGI's Photo Vista™ or any other digital image processing software which provides this capability. While the use of a panoramic photograph is

preferred, it is possible to use a wide angle photograph covering less than a three hundred and sixty degree panorama. As reduced a photograph as one covering one hundred and eighty degrees has been successfully employed by the present inventor, and even smaller photographs may be employed, but for the best results a full panoramic photograph is presently preferred.

[0031] At step 112, the process continues with capturing video of the object to be displayed. There are presently two techniques for capturing video of an object to be displayed, the first technique for real objects and the second technique for virtual objects.

[0032] If the object to be displayed is real, then the survey information obtained in step 104 is used to construct a mocking stage. The mocking stage recreates the lighting conditions and effects of the objects of interest, such as pillar 240, which exist at the target location such that, when the object to be displayed is located at the target location on the mocking stage, it is subject to the visual highlights, including specular highlights, shadows, ambient light levels and colors and the other lighting characteristics it would be subject to at the target location at the site. As will be apparent to those of skill in the art, the mocking stage need not be constructed on a 1:1 scale and can instead be scaled to a reasonable size, as needed, by scaling the physical relationships between the lights and objects of interest and the target location and by adjusting the lighting levels of the light sources on the mocking stage corresponding to the scale changes.

[0033] The back of the mocking stage is provided with a chromakey back drop to allow for removal of the background from the captured video image. As is known to those of skill in the art, chromakeying allows for the removal of undesired backgrounds from video images, by removing any portion of an obtained image which has a specified color. Thus an object place in front of a blue, or green, etc. backdrop can be filmed and the background will be removed by the chromakey system.

[0034] Once the mocking stage is constructed, the object is placed at the target location and the camera is placed at the location where screen 204 would be with respect to target location at the site. As will be apparent, the focal length of the lens on the camera is selected such that the filmed object will be appear at the right size and at the desired distance behind screen 204 when projected.

[0035] As mentioned above, the present inventor has determined that one factor in having the human visual perception system consider a displayed object as a three dimensional image, is movement of the object at a sufficient rate. The movement can be rotating of the object about an axis extending at an angle of between 50 and 90 degrees to a plane extending between the intended viewer's eyes. In most cases, this plane will be horizontal plane although it may have different orientations if the viewers are not expected to be in an upright position, etc.

[0036] A turntable or other mechanism is employed to rotate the object at the desired orientation and speed. This turntable, or other mechanism, is also colored such that it is removed from the captured video image by the chromakeying system. The rotational velocity of the object, necessary to take advantage of the characteristics of the human visual perception system to make the object appear as three dimensional, can be determined empirically, for example by capturing video of the object and displaying the result on screen 204. The present inventor has determined that a rotational velocity which results in a movement of the outer edges of the final projected image of the object moving at least 5% of the size of the object, as measured parallel to a plane through the viewer's eyes, per second is an approximate minimum rotational velocity, although other rotational velocities will be appropriate in other circumstances. In other words, if an object measures three inches across on the above-mentioned plane, the rotational velocity should be selected such that a point on the object will move 5% of the three inches, along the plane, in one second. In other words, a point on this object on the plane of the viewer's eyes should move about 0.15 inches along the plane in one second.

[0037] While it is contemplated that values as low as 3% can work in some circumstances, the present inventor has determined that, for the best results, a value of about 5% is desired.

[0038] If the object is translating, rather than rotating, the 5% value also applies. In other words, a three inch wide object translating from one side to the other should move fast enough that its edges cover 0.15 inches in a second. If the object is both rotating and translating, the translation and rotation rates need to be selected such that a point on the edge of the object still moves the about 5% of the size of the object along the plane of a viewer's eyes. Thus if the object is rotating clockwise about an axis orthogonal to the plane, so that the front of the object is rotating right to left, and the object is also translating right to left, the speed of the rotation is added to the speed of translation for an observed point on the object and each movement can be slower than would be required on its own. Conversely, if the object is rotating clockwise and translating left to right, the speed of the translation is subtracted from the speed of the rotation and thus the speed of rotation would likely have to be increased to ensure that the desired movement of about 5% is still obtained.

[0039] Once the desired motion of the object is arranged, the object is captured with the camera as it is rotated and/or translated for the required period of time. The captured image is then processed by the chromakey system to remove the background, turntable and any other undesired components.

[0040] The above-mentioned requirement for translational and/or rotational movement of the object is actually not an absolute, it is instead relative to the background in the viewer's visual field. Thus, if a background is included in the image displayed, the object can be motionless if the background moves about 5% relative to the size of the object along a plane extending through the viewer's eyes. For

example, the above-mentioned three inch object can be motionless if a background wall covered with spots is shown to be moving behind the object, with the features of the wall (e.g. – the spots) moving left to right or right to left at 0.15 inches per second. The required degree of movement between an object and a displayed background is relative and thus if both the background and the object are moving, only their net difference in their speed of movement must equal about 5%. In our example of the three inch object, if the background moves left to right at 0.06 inches per second, then the object would need to translate from right to left at 0.09 inches per second to achieve the desired rate of movement.

[0041] The present invention can also be employed with virtual objects comprising objects modeled and rendered by a three dimensional computer rendering system, such as Avid's SOFTIMAGE 3D, Alias' Maya, etc. If the object is a virtual object a similar procedure to that described above for real objects is followed. Specifically, a lighting configuration that matches that determined in step 104 is defined for the rendering of the object model and any objects of interest, such as pillar 240 are also modeled and positioned in the lighting configuration for the rendering. The camera (i.e. – the rendering viewpoint) is defined at the target location in the rendering and an animation is then defined for the object, the animation defining the rotation and/or translation of the object. The same conditions exist for the speed of movement of the object as discussed above for real objects. The animation of the object is then rendered, under the defined lighting conditions, to capture the necessary video.

[0042] At step 116, a reflection map is applied to the captured video of the real or virtual object, the reflection map being constructed from the panoramic photograph obtained at step 108 and, when applied, results in reflections of objects and the surroundings at the target location of the site being visible on appropriate portions of the final displayed image of the object. In the case of a real object, the reflection map is created from the panoramic photograph and applied to the captured video of the object with commercially available software, such as Combustion Studio or Adobe Photoshop. In the case of virtual objects rendered by a computer 3D animation system, the reflection map can be included in the rendering process. If a background is to be included in the final image, it can also be composited into the image at this point.

[0043] As mentioned above, the display of visual highlights (e.g. – specular highlights, reflections of surroundings, etc.) on the object in the final image that are appropriate for the object's surroundings, exploits the characteristics of the human visual perception system such that the viewer will attempt to perceive the display as a three dimensional one. The combination of the rotational movement of the object in the final image and the presence of the correct visual highlights lead the viewer's visual perception system to see the final image as being three dimensional.

[0044] Finally, at step 120, the resulting finished image 208 is projected, by projector 212 onto screen 204 at the site. The final image can be provided to projector 212 from a computer system, DVD, or can be rendered to film and projector 212 will be a motion picture projector, etc.

[0045] As mentioned above, it is presently preferred that screen 204 be a clear rear projection screen and thus the displayed image 208 is displayed flipped (mirror imaged) from the orientation it was captured in (this mirror imaging can be achieved by mechanical means – a mirror in the projection path – or via the image processing or animation software used to create the final image. However, it is also contemplated that front projection screens can be employed and, in such a case, no mirror imaging of the final image will be required.

[0046] The embodiment discussed above contemplates a final image that has been prepared and created prior to showing the display. It is also contemplated that the final image can be created in real time, or near real time, in other circumstances. While the embodiment above provides good results, the overall effect can be further improved if the final image is created in real time to display visual highlights of the current environment of the display. For example, no viewing audience is included in the reflection map determined at step 108. As used herein, the term "real time" is used generically to describe a situation wherein updates are provided within the bounds of the perception of the human visual perception system. It is not presently believed to be necessary to update visual highlights such as reflections more than about once every one or two seconds.

[0047] Accordingly, in a real time embodiment of the present invention, the reflection map, including the viewing audience and other surroundings, can be captured from one or more cameras mounted about screen 204 at intervals and a new, updated, reflection map created. This updated reflection map can then be applied to the captured video of the object, if it is a real object, or used to re-render the object if it is a virtual object, and this updated image is then used as the final image on screen 204. As will be apparent to those of skill in the art, significant computational resources may be required to perform the processing of the final image to update the reflection map, but such resources are readily available and their costs are decreasing rapidly.

[0048] In the embodiment of Figure 2, a single screen 204 and single projector 212 are provided which allows viewing of the final image over the viewing angle supported by screen 204. Figures 3 and 4 show another embodiment of the present invention wherein screen 204 rotates and multiple projectors 212 are employed to provide appropriate final images over three hundred and sixty degrees of viewing.

[0049] Specifically, in this embodiment, screen 204 is mounted to the center of a dish 300 which is rotatably mounted to motor 304 which rotates dish 300. In a presently preferred embodiment, dish 300 is rotated at an even multiple of the frame rate of the final image. If the final image has a frame rate of

thirty frames per, dish 300 is rotated at thirty revolutions per second, thus each projector 212 displays its image on screen 204 at its full frame rate.

[0050] The outer edge 308 of dish 300 is inclined upwardly with respect to the base of dish 300 and an aperture 312 is provided through outer edge 308 behind screen 204. Projectors 212 are inclined such that, when aperture 312 is in front of them, they can project an image through aperture 312 and on to screen 204. When aperture 312 is no longer in front of a projector 212, that projector's output is blocked by edge 308.

[0051] In the illustrated embodiment, eight projectors 212 are provided, although only one is illustrated in Figure 4 for clarity, and as will be apparent to those of skill in the art, more or fewer projectors 212 can be employed as desired. If more projectors 212 are employed, it may be desired to vertically stagger the projectors and to provide additional, vertically and horizontally staggered apertures 312 in the edge 308 of dish 300 to allow the projectors to be physically mounted within a reasonably small area.

[0052] To create a final image (either static or real time) for the embodiment of Figures 3 and 4, the process described above, with reference to Figure 1, is employed for the viewpoint of each projector 212 to create the eight final images to be displayed.

[0053] It is presently preferred that aperture 312 be somewhat elliptical (having the major axis of the ellipse parallel to the base of dish 300) to ensure that the final image is projected from a projector 212 onto screen 204 through a reasonable portion of the rotation of screen 204. When the above-described HoloPro™ rear projection screens are employed as screen 204, screen 204 can display a reasonable image when it is rotated as much as twenty two and a half degrees off axis from the centerline of a projector 212, thus allowing screen 204 to rotate through as much as forty five degrees while displaying the final image. While eight projectors 212 can thus provide project images for a full three hundred and sixty degrees of viewing, aperture 312 is preferably sized such that it rotates from being in front of one projector 212 to being in front of another projector 212, there is a period wherein the output of both adjacent projectors 212 is blocked. In this manner, no confusing overlap of two images occurs on screen 204 while dish 300 rotates.

[0054] The present invention is believed to provide significant advantages over two dimensional displays for purposes such as advertising and marketing, museum displays, educational system, etc. wherein the extra attention that a three dimensional display can attract will be most beneficial. By producing a final image which has been tailored to exploit appropriate characteristics of the human visual perception system, a simple yet effective display is obtained.

[0055] The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.

I claim:

1. A method of creating a final image which, when displayed at a target location, is perceived by viewers as being three dimensional, comprising the steps of:

(i) selecting a target location for the display at a display site;

(ii) surveying the display site to identify and characterize light sources and objects which would result in visual highlights on a object displayed at the target location;

(iii) capturing a wide angle photograph of the display site about the target location;

(iv) capturing video of the object to be displayed under a recreation of the characterized light sources and objects surveyed at the target location, the object moving in the video along a plane extending through the eyes of expected viewers;

(v) applying the captured wide angle photograph as a reflection map to the captured video of the rotating object to create a final image; and

(vi) displaying the final image at the site onto a screen positioned such that the final image appears at the target location.

2. The method of claim 1 wherein in step (iii) a panoramic photograph is captured.

3. The method of claim 1 wherein in step (iv) a mocking stage is constructed to recreate the light sources and objects characterized in step (ii), the object is placed on said mocking stage in front of a chromakey backdrop and the video of the object is captured in step and the background removed by a chromakey process in step (iv).

4. The method of claim 1 wherein in step (iv) the characterized lights and objects from step (ii) are employed in computer animation system to light a model of the object to be displayed, step (iv) comprises rendering a video image of the object in said computer animation system and step (v) comprises applying the reflection map during the rendering process.

5. The method of claim 4 wherein steps (iii) and (v) are performed iteratively to update reflections on the final image as the surrounding environment changes about the target location.

6. The method of claim 1 wherein the movement of the object is performed such that a point on the object along the plane of the expected viewers eyes occurs at a rate of about at least three

percent of the size of the object, measured through that plane, per second relative to the background.

7. The method of claim 6 wherein the rate of movement is about at least five percent of the size of the object, measured through that plane, per second relative to the background.

8. The method of claim 7 wherein the movement is rotational movement of the object about an axis not exceeding 40 degrees from an axis orthogonal to the plane of the expected viewers eyes.

9. The method of claim 7 wherein the movement is translation movement across the display along the plane of the expected viewers eyes.

10. The method of claim 7 wherein the movement is a combination of translational movement and rotational movement.

11. The method of claim 7 wherein the background is the background behind the screen.

12. The method of claim 6 wherein the background is provided in the final image.

13. The method of claim 12 wherein the background moves.

14. A system for displaying on a two dimensional display at a target location a final image of at least one object, the final image being perceived by viewers as a three dimensional image, comprising:

a screen onto which the final image is displayed;

a projector to display the final image onto the screen; and

a video source providing a final image to the projector, the final image having visual highlights corresponding to the surrounding environment at the target location and showing the object moving such that a point on the object along a plane of the expected viewers eyes occurs at a rate of about at least three percent of the size of the object, measured through that plane, per second relative to the background.

15. The system of claim 14 further comprising a wide angle camera to intermittently capture a wide angle image of the surroundings from the target location and the video source employing the captured image as a reflection map to modify the visual highlights of the displayed final image.

16. The system of claim 14 further comprising at least four projectors and wherein the screen rotates such that a different one of each projector displays a different final image on the screen at different times.

17. A method of having the human visual perception system perceive an observed image of an object on a two dimensional display at a target location as a three dimensional image, comprising the steps of:

(i) moving the object in the image such that a point on the object along a plane of the expected viewers eyes occurs at a rate of about at least three percent of the size of the object, measured through that plane, per second relative to the background;

(ii) applying visual highlights to the object in the image, the visual highlights including specular highlight and shadows appropriate for the object at the target location; and

(iii) obtaining a wide angle image of the surroundings of the target location and applying this wide angle image as a reflection map to the final image of the object.

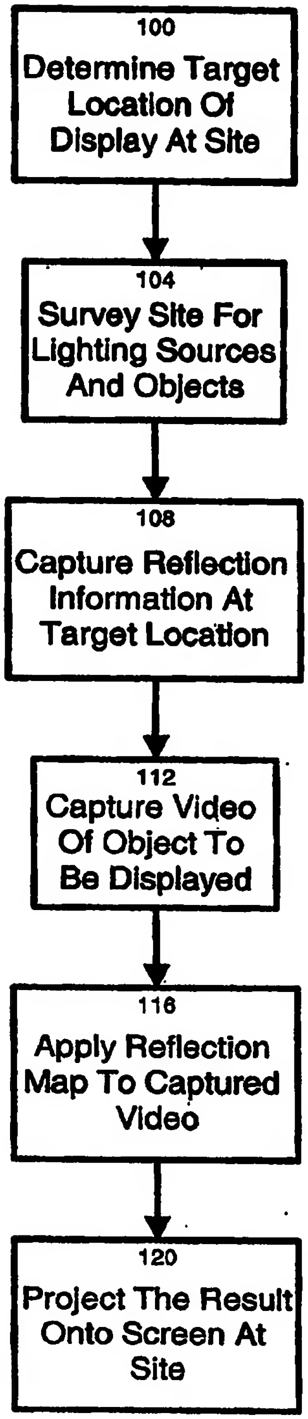
100
Determine Target Location Of Display At Site
104
Survey Site For Lighting Sources And Objects
108
Capture Reflection Information At Target Location
112
Capture Video Of Object To Be Displayed
116
Apply Reflection Map To Captured Video
120
Project The Result Onto Screen At Site

Fig. 1

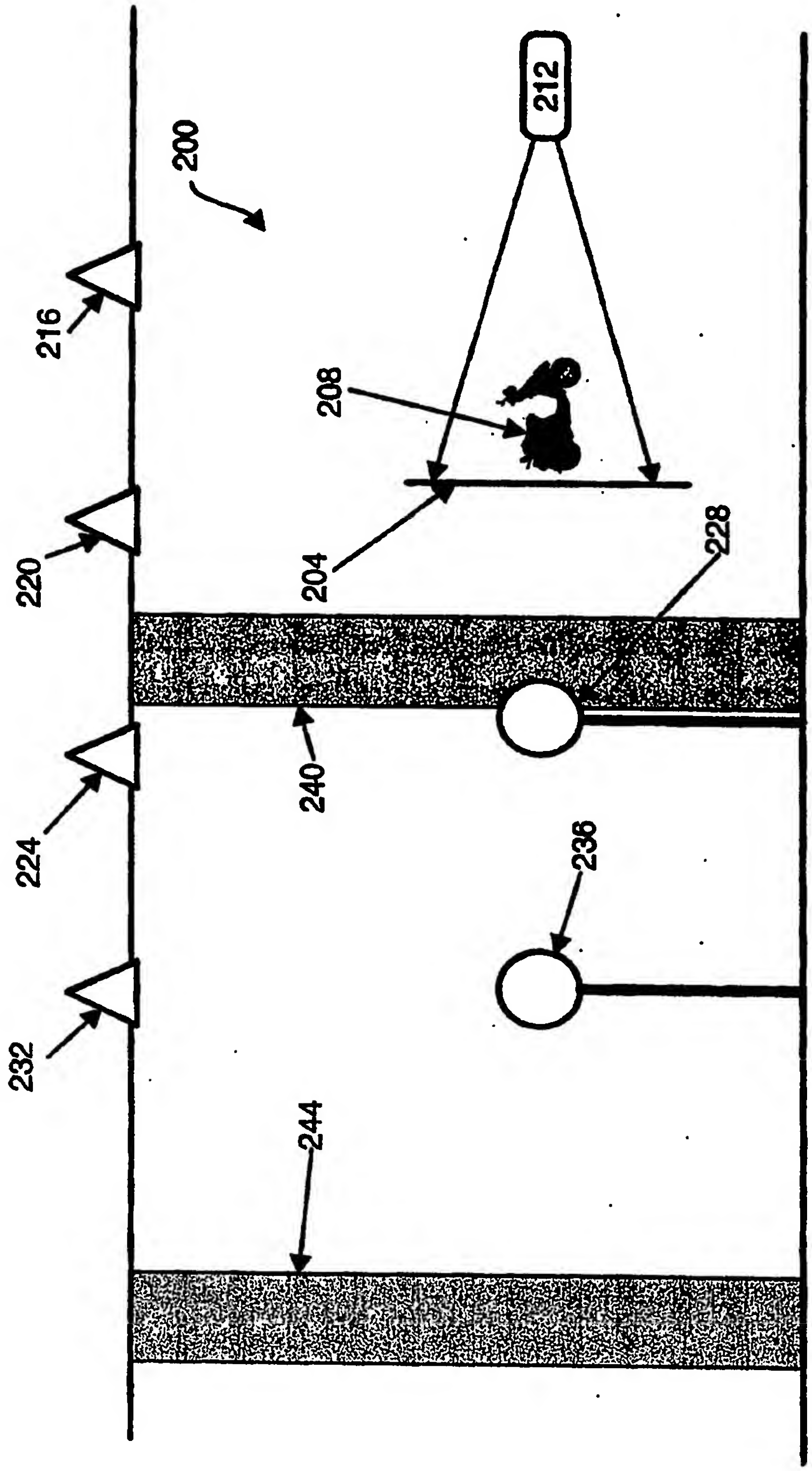

Fig. 2

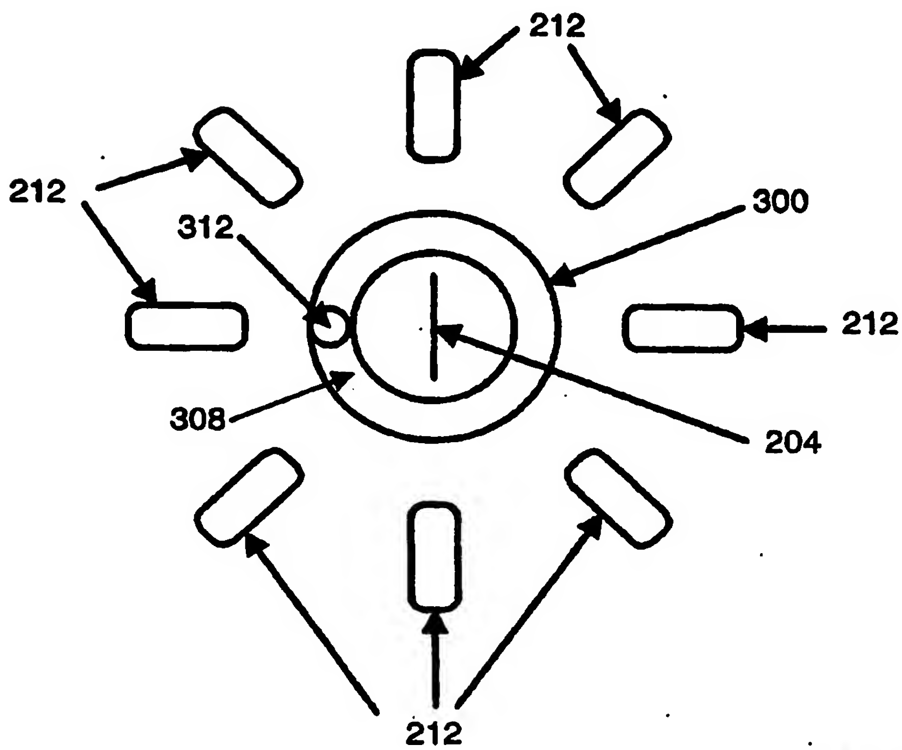

Fig. 3

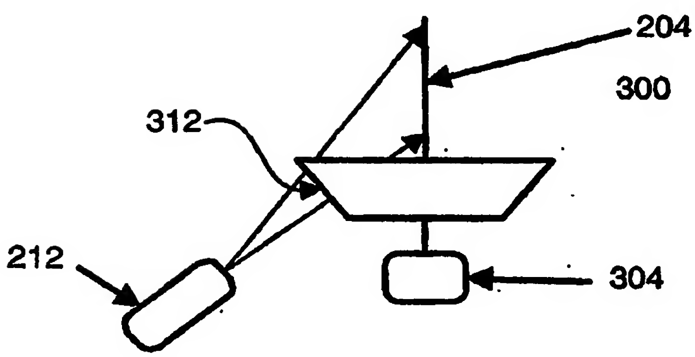

Fig. 4